Appendix 5: Chemical Kinetics Problems - Answer Key

1. Reactions the produce a gas (measure volume/pressure); reaction that involve the ion as a product (conductivity); reactions that produce a colour change (spectrometer-measure colour intensity)

2. (a) colour change ($Fe^{2+} \rightarrow Fe^{3+}$)
   (b) volume/pressure (H_2(g) produced)

3. mol / L·s

4. $3\ H_2 + N_2 \rightarrow 2\ NH_3$

   The rate of disappearance of H_2 is 3 times as fast as compared to the rate of disappearance of N_2.

   $3\ H_2 + N_2 \rightarrow 2\ NH_3$

   The rate of production of NH_3 is 2 times as fast as compared to the rate of disappearance of N_2.

5. Rate of consumption of A is

   $2\ A + B \rightarrow 3\ C$

   is twice (2x) the rate of consumption of B (0.30 mol / L·s)

   = 2 x 0.30 mol / L·s

   = 0.60 mol / L·s

   Rate of formation of A is

   $2\ A + B \rightarrow 3\ C$

   is three times (3x) the rate of consumption of B (0.30 mol / L·s)

   = 3 x 0.30 mol / L·s

   = 0.90 mol / L·s

6. $2\ N_2O_5 \rightarrow 4\ NO_2 + O_2$

   2:4 ratio which simplifies to a 1:2 ratio

   The rate of formation of NO_2 is 2 times as fast as compared to the rate of disappearance of N_2O_5.

   rate of formation of NO_2 = 2 x 2.5 x 10^{-6} mol / L·s = 5.0 x 10^{-6} mol / L·s

$2\ N_2O_5 \rightarrow 4\ NO_2 + O_2$

The rate of formation of O_2 is 1/2 times as fast as compared to the rate of disappearance of N_2O_5.

rate of formation of O_2 = 1/2 x 2.5 x 10^{-6} mol / L·s = 1.25 x 10^{-6} mol / L·s

7.(a) $I^-_{(aq)} + OCl^-_{(aq)} \rightarrow Cl^-_{(aq)} + OI^-_{(aq)}$

$$\text{Rate} = \frac{-\Delta[I^-]}{\Delta t} = \frac{-\Delta[OCl^-]}{\Delta t} = \frac{\Delta[Cl^-]}{\Delta t} = \frac{\Delta[O^-]}{\Delta t}$$

(b) $3\ O_{2(g)} \rightarrow 2\ O_{3(g)}$

$$\text{Rate} = -\frac{1}{3}\frac{\Delta[O_2]}{\Delta t} = \frac{1}{2}\frac{\Delta[O_3]}{\Delta t}$$

(c) $4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

$$\text{Rate} = -\frac{1}{4}\frac{\Delta[NH_3]}{\Delta t} = -\frac{1}{5}\frac{\Delta[O_2]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO]}{\Delta t} = \frac{1}{6}\frac{\Delta[H_2O]}{\Delta t}$$

(d) $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$

$$\text{Rate} = -\frac{\Delta[CH_4]}{\Delta t} = -\frac{1\Delta[O_2]}{2\ \Delta t} = \frac{\Delta[CO_2]}{\Delta t} = \frac{1\Delta[H_2O]}{2\Delta t}$$

8. (a) $[CH_4] = \frac{\text{mol}}{\text{L}} = \frac{8.0\text{ mol}}{2.00\text{ L}} = 4.0$ mol / L

Rate of consumption of CH_4 = $\frac{\text{concentration}}{\text{time}} = \frac{4.0\text{ mol / L}}{3.2\text{ s}}$ = 1.25 mol / L·s

(b) Rate of consumption of O_2

$CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$

The rate of consumption of O_2 is 2 times as fast as compared to the rate of consumption of CH_4 is

2 x 1.25 mol / L·s = 2.50 mol / L·s

(c) Rate of production of CO_2

$$CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$$

The rate of production of CO_2 is the same as compared to the rate of consumption of CH_4 is

1 x 1.25 mol / L·s = 1.25 mol / L·s

(d) Rate of production of H_2O

$$CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$$

The rate of production of H_2O is 2 times as fast as compared to the rate of consumption of CH_4 is

2 x 1.25 mol / L·s = 2.50 mol / L·s

9. (a) $4\,HI_{(g)} + O_{2\,(g)} \rightarrow 2\,I_{2(g)} + 2\,H_2O_{(g)}$

The rate of formation of I_2 is 2 times as fast as compared to the rate of consumption of O_2.

= 2 x 0.0042 mol / L·s = 0.0084 mol / L·s

(b) $4\,HI_{(g)} + O_{2\,(g)} \rightarrow 2\,I_{2(g)} + 2\,H_2O_{(g)}$

The rate of formation of H_2O is 2 times as fast as compared to the rate of consumption of O_2.

= 2 x 0.0042 mol / L·s = 0.0084 mol / L·s

(c) $4\,HI_{(g)} + O_{2\,(g)} \rightarrow 2\,I_{2(g)} + 2\,H_2O_{(g)}$

The rate of consumption of HI is 4 times as fast as compared to the rate of consumption of O_2.

= 4 x 0.0042 mol / L·s = 0.0168 mol / L·s

10. (a) $4\,NO_{2(g)} + O_{2\,(g)} \rightarrow 2\,N_2O_5$

The rate of formation of N_2O_5 is 2 times as fast as compared to the rate of consumption of O_2.

= 2 x 0.024 mol / L·s = 0.048 mol / L·s

(b) $4\ NO_{2(g)} + O_{2\ (g)} \rightarrow 2\ N_2O_5$

The rate of consumption of NO_2 is 4 times as fast as compared to the rate of consumption of O_2.

$= 4 \times 0.024\ mol / L{\cdot}s \ = \ 0.096\ mol / L{\cdot}s$